

The concept of smartness based on the level of technology: a case of system smartness in higher education institutions in Indonesia

Arry A. Arman†, Radiant V. Imbar†‡, Suhono H. Supangkat† & Armein Z.R. Langi†

Bandung Institute of Technology, Bandung, Indonesia†
Maranatha Christian University, Bandung, Indonesia‡

ABSTRACT: Currently, there are many educational systems in Indonesia that claim to be smart. Some claim to be smarter than others. However, perceptions of system smartness differ greatly because the standard for measuring smartness has not been well defined until now. This study presents a representative model of system smartness in terms of the level that technology has been applied to run the smart cycle. Measurements were taken from 36 HEIs in Indonesia to evaluate the smart system model and the measurement tools that have been created. It is hoped that the results of this research will have a major impact on higher education, and be especially useful for those higher education institutions (HEIs) for whom achieving smartness remains a challenge. This research will make it easier for them to identify their smartness level and enable them to move towards a more technology-intensive system. The developed model can also serve as a guideline for other researchers who want to measure the smartness of a system.

INTRODUCTION

The term *smart* is usually used to describe the use of technology; i.e. smart home, smart campus, smart city or more generally, a smart system. According to the Merriam-Webster Dictionary, the term *smart* means operating by automation and can be applied to a device or system that operates automatically. Jason et al interpret *smart* as having the ability to make adjustments in response to changing circumstances [1]. Costa et al define *smart* as being equipped with cognitive abilities and being able to sense, process and connect with other systems [2].

Some sources define a smart system as a system that uses the Internet of Things (IoT), big data and AI applications [3][4]. There is nothing wrong with that definition of a smart system; however, if a system does not use these applications does that mean it is not smart? Romero et al define a smart system as a system that can learn and adapt to new situations [5]. A smart system is a system that assists users in making decisions by combining available data from various sensing systems to control and perform intelligent actions. Smart actions consist of augmenting the user's actions and/or decisions by using additional devices or information. A smart system must be able to optimise its performance against various inputs and be able to recover quickly in various uncertain situations. According to IBM, a smart system is a system that can sense and has smartness to be able to understand the situation, so that it can predict the course of action based on adaptive data [6].

Returning to the generalised definition of a smart system as discussed above and considering other studies [7][8], it could be observed that the key role that technology plays is in carrying out the smart cycle. Usage intensity of technology is increasing with the growing shift from human-intensive systems to technology-intensive systems. Until now, however, no smart system measurement model has been developed from the perspective of this shift. Therefore, a measurement model is definitely needed to measure the smartness level of a smart system.

In this article, the authors propose a smart system model. Based on the model, they also propose a smartness level representative model to measure the smartness level or degree, to which technology has been applied in executing the smart cycle. This study addresses the research question: *How can the level of technology usage be represented in the continuum as human-intensive systems transition to technology-intensive systems?* The continuum will start from a fully-human executed system to a fully technologically-executed system. Each level of the continuum will also be clearly described. The proposed model was also thoroughly evaluated as a case study in a HEI environment.

The novelty of this research lies in the representative smartness model of the smart system as it moves from a human-intensive system to one that is technology-intensive. The researchers hope that the proposed representative model and measurement instrument will have a major impact on facilitating the identification of smartness levels as HEIs progress towards an ever-smarter system. This article will also contribute to the body of knowledge regarding smart systems by enriching new, or representational, perspectives, as well as new measurement models.

The limitations of this research are that the measurement of smartness was made solely from the point of view of the use of technology, and the test was carried out only in institutions of higher education. In the future, it would be advisable to try out the test in other environments, such as smart cities.

RESEARCH METHODOLOGY

As explained above, this study aims to develop a model that can measure the smartness level of a smart system based on the intensity of technology usage to automate the smart cycle processes. Design science research methodology (DSRM), which is commonly used in the field of information systems to design artefacts, was used in this study [9]. In this case, the artefact is a model designed to measure the smartness level of a smart system.

The methodology of this research starts with identifying the problem, which has already been described in the introduction. The next stage involves determining the objectives of the research; this is obtained by conducting a literature review to determine the requirements needed for the model to be created. The third stage is designing the smartness levels based on the use of technology in the smart cycle, as well as designing questions for the assessment process of the system being measured. The fourth stage is evaluating the design in terms of the requirements for the smartness levels. Finally, expert judgment is used to evaluate the impact of the model [10]. This evaluation is applied to measuring the smartness level system in several HEIs in Indonesia.

The questionnaire used in the measurement is evaluated using construct validation. Construct validity is determined using Pearson's product moment correlation value, and reliability is determined using Cronbach's alpha coefficient. Content validation is carried out to test the feasibility and relevance of the evaluation of the created smartness level measurement tool. Lawshe's content validity ratio (CVR) is used in this study [11].

This article is organised as follows: the introduction covers the first stage of DSRM, while in this section the applied methodology is discussed. The literature review is covered in the second stage of DSRM. Design and development are covered in the third stage of DSRM. The section on evaluation covers the fourth stage of DSRM. The conclusion encompasses the contributions and limitations of this research, thus bring the article to an end.

LITERATURE REVIEW

From the various definitions of a smart system above, the researchers conclude that a smart system must have several characteristics; namely, having sensing or perception as input from the system and having the smartness to be able to adapt to changing situations. The system can also describe and analyse situations, make decisions and act automatically. From these characteristics, it can be seen that a smart system is one that can rationally solve problems as humans do, and all smart cycles are carried out automatically.

The cycle of a smart system consists of the processes involved in sensing, understanding, decision making, action and learning. From the above definitions, the specifics of a smart system model can be defined, as seen in Table 1.

Table 1: Specifications of a smart system model.

Smart system model	
Ability	• To sense, understand, make decisions, act and learn • To communicate with other systems
Impact	Provide solutions for system users
Input	Data
Output	Information, action

Previous studies have proposed ideas for determining the level of smartness of a system. Research done by Alter [12] bases the level of system smartness on four characteristics: information processing, internal regulation, action in the world and knowledge acquisition. These characteristics are categorised in different levels: having a degree of smartness, not smart at all, scripted execution, formulaic adaptation, creative adaptation and unscripted or partially-scripted, invention. Imbar et al categorise system smartness based on three perspectives: anthropocentric, systemic and technological [13]. The level of smartness is determined based on these three perspectives.

Costa et al divide smartness into 12 levels based on the capabilities of the system [2]. These are: traceability, internal state awareness, context state awareness, remotely manual-driven, reactively self-driven, collaborative and reactively self-driven, collaborative and adaptively self-driven, autonomous and reactively self-driven, collaboratively autonomous and reactively self-driven, autonomously adaptively self-driven, collaboratively autonomous, adaptively self-driven.

Based on several studies that discuss the level of system smartness, in this study an attempt is made to discuss the level of smartness based on the use of technology. Thus, indicating that if all cycles of smart systems are carried out automatically by the system, the level of smartness increases. The opposite is also true: if all cycles of smart systems are carried out by humans, the level of smartness decreases.

In this study, it is proposed that the operation of a smartness level representative model be based on the level or degree of technology used to run the smart cycle. Table 2 contains the specifications of the smartness level.

Table 2: Specifications of the smartness level.

Smartness level	
Requirement	• Each smart cycle has one or more processes • Each level has a clear difference between it and the next level
Impact	Can distinguish the smartness level of the system
Input	System
Output	Smartness level of the system

After defining the smartness level, it is also necessary to develop a tool to measure the smart system, so that the smartness level of a system can be determined. Table 3 contains the specifications needed for a measuring tool that can measure the smart system.

Table 3: Specifications of a smartness level measurement tool.

Measurement tools	
Requirement	• Each question can interpret the smartness level of the system • Each question must be dichotomous (yes/no) • Every answer must be provable
Impact	Can measure the level of system smartness
Input	Questions
Output	Answer (yes/no)

Currently, institutions of higher education are being transformed through the use of information technology to increase instructor and student interest in teaching/learning, as well as to improve teacher-student relationships by enriching the campus life of both teachers and students [14]. To succeed in such an era of academic disruption, HEIs need to adapt and be willing to accept changes. As a result, HEIs are used as a test to determine how smart HEIs are in using a fully technologically executed system.

DESIGN AND DEVELOPMENT

Based on the requirements and specifications described and analysed above, the following subchapters discuss the design to be developed.

Designing a Smart System Model

A smart system model receives input data from either a form or an existing sensor, which is called sensing. After the sensing process, the cycle will continue to understanding, which is the process of translating information that can be used to generate alternative courses of action for the next step. The decision-making and action-taking stage is then entered upon. At this stage, the smart system model will choose the best solution from a set of alternatives based on a variety of criteria and act to produce the expected result. At each stage, from sensing to acting, a learning process will be carried out that is aimed at improving cognitive skills based on the information-handling experience. Figure 1 shows a smart system model designed based on the previously analysed requirements.

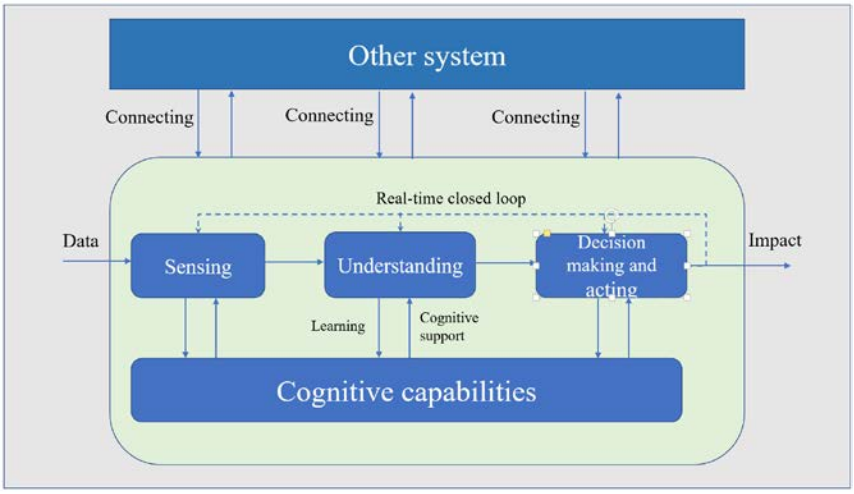

Figure 1: Smart system model.

Designing the Smartness Level

A unique approach is proposed in dividing the levels of system smartness based on the degree of technological applications used to run the smart cycle. The basis for using this approach is the current era of society referred to as Society 5.0, where information generated by machines (technology) is replacing that of humans [14][15].

In recent years, society has gradually moved towards an ecosystem, where physical and virtual dimensions are increasingly interconnected. This growing ecosystem is expected to cause greater interaction among humans, machines and digital technology to better serve the needs of society. This has caused a dramatic shift in today's world. In the past, most systems were operated by humans, while technology helped to simplify tasks undertaken by humans. Today, however, information technology is replacing human effort. As a result, a smart perspective is needed to understand how best to replace the human role.

In this study, the levels of smartness have been divided based on the level of technology used by a system. The smartness level of a system must meet the requirements and indicate through levelling from the bottom to the top what role humans play and what role technology plays. It can be concluded that the greater the role of technology, the smarter the system.

For this reason, the smart system cycle has been divided into processes that are carried out in each cycle, starting with sensing, which consists of collecting data. Understanding then follows, which consists of pre-processing data and analysing existing data. The process of making decisions based on the results of analytic data will then be undertaken. After several scenarios are generated, a decision will need to be made. Taking action will consist of choosing the best decision given at the time of decision making, while learning is the process of gaining knowledge from the decisions that were made.

The capability maturity model (CMM) introduced by the Software Engineering Institute (SEI) was used to build the technology-based smartness levels. The CMM was used to evaluate the level of technology applied in a system, so that the current state of technological application of the existing system can be determined in order to assist organisations in creating a technology development roadmap of the system. Table 4 describes each process that occurs in the cycle of the smart system and the smartness level. Table 5 contains an explanatory description of each level of system smartness.

Table 4: Smartness level per process.

Smart cycle	Process	Human ←--------------------------------→ Technology					
		0	1	2	3	4	5
		Human-based	Sensed by technology	Analysed by technology	Decided by technology	Smart	Super-smart
Sensing	Collecting	H	T	T	T	T	T
Understanding	Data pre-processing	H	H	T	T	T	T
	Data analytics	H	H	T	T	T	T
Decision	Low-risk decision	H	H	H	T	T	T
	High-risk decision	H	H	H	H	T	T
Action	Action	H	H	H	H	T	T
Learning	Learning	H	H	H	H	H	T

Key: H = executed by humans; T = executed by technology

Assumptions: Process orientation and data representation are already in digital form.

Table 5: Description of the levels.

Level	Name	Description
0	Human-based	• All processes in the cycle are carried out by humans. • Data representation is already in digital form. The data capture process is still entered manually by humans.
1	Sensed by technology	• Data collection is carried out using technology assistance, ranging from barcodes, QR codes, contactless devices, or IoT in general, to simple CCTV analysis. • If data is sourced from other parties/systems, it is retrieved automatically by the system without human involvement.

2	Analysed by technology	• There are specific analytical processes based on big data and machine learning for very specific purposes; for example, specialised analysis in the medical field, the transportation sector, banking, etc. • The results of the analysis are presented to humans as the decision- makers.
3	Decided by technology	• There is a firm determination of high-risk and low-risk decision criteria. • Low-risk decisions are made directly by the system without human involvement. • High-risk decisions are presented for decision making by humans.
4	Smart	• Level 3 has been going on for a long time with evaluation and improvement. Smart systems reach the level where all decisions are made automatically and immediately followed up with action. For example, the decision to approve credit applications and direct funds transfer actions. • Up to level 4, the running system is designed by humans with a certain level of performance; there is no self-learning mechanism.
5	Super smart	• There is a self-learning mechanism; the cognitive ability of the system increases with the learning mechanism from new data as long as the system operates.

Designing Smartness Level Measurement Tools

In this study, questions were also designed that would be asked in the interview and to make observations about the system that would check the level of smartness. The following are examples of questions asked:

1. Can the system collect data automatically (in the sense that the system is designed to collect information continuously without human involvement)? Yes or no.
2. If *yes*, can the system perform data processing to data analytics, so that humans only need to make decisions (for example, the decision support system)? Yes or no.
3. Since the Fourth Industrial Revolution (4IR), there has been a shift to where more and more decisions are not made by humans, especially non-strategic, low-impact decisions; for example, credit decisions at banks can now be done without humans to a certain credit limit. Is the system able to make decisions from the results of data analytics that have been carried out? Yes or no.
4. Can the system take action automatically after a decision is made by the system; for example, if the air defence system is set up to defend from missiles, will the system immediately take action when a missile attack enters its territory? Yes or no.
5. If *yes*, can the system carry out the learning process? Yes or no.

At this stage, the design model had to be tested to see whether it met the requirements that had been defined earlier. Also, the created model had to be evaluated, using the expert judgment method. The measurement model has been used to measure the supporting systems in 36 HEIs in Indonesia.

Demonstration

The smart system model that has been made follows the necessary requirements; i.e. a smart system that can sense, understand, make decisions, act and learn. All the cycles of the smart system have been described in Figure 1. Additionally, smart systems must also be able to communicate with other systems. Figure 1 shows that the smart system fulfils this requirement, as well and can relate to other systems.

Furthermore, testing was carried out on the requirements of the smartness levels which requires that each cycle of the smart system consist of one or more processes. It can be seen in Table 4 that each smart cycle consists of one or more processes; i.e. the sensing cycle consists of one data-collecting process. For the next requirement, each level differentiates between the processes that are carried out by humans and those that are carried out by technology. There is also no overlap at each level.

Testing the requirements of the smartness level measurement tools was done by checking whether the questionnaires were valid and reliable. Construct validity was determined using Pearson's product-moment correlation value, and reliability was determined using Cronbach's alpha coefficient. A construct validity test is needed to ensure the validity of the questions, using IBM SPSS Statistic 25 [16]. The criteria used to determine whether the questions were valid are: the sig (p-value) < 0.05 and the value of r count $\geq$ r table. In this study, the r count for each question was > 0.8. A minimum of 30 samples is needed to conduct validity and reliability test. In this research, total 50 respondents from each campus were selected. Thus, it can be concluded that all the questions were valid.

A reliability test is used to show the extent to which a measuring instrument can be trusted or reliable. This study used Cronbach's alpha. If the Cronbach's alpha value is > 0.60, then the questionnaire is considered reliable or consistent. The questionnaire in this study obtained a Cronbach's alpha value of 0.833.

The test of smartness level measurement tools was used to measure system smartness in the HEI environment. Measuring smartness for the entire system of an HEI is very difficult because universities provide many services to stakeholders. It is thus necessary to ask how a large system like that of an HEI can be measured. This must be determined based on the services a system produces for stakeholders; i.e. an HEI provides academic services for students. Such academic services can be divided into new student admissions, academics and e-learning systems. In addition to academic services, the HEI also provides administrative services supported by the e-office, dashboard, finance and scholarship, library, and human resources systems.

Measurements on 36 HEIs in Indonesia were conducted as an example of testing accuracy of the smartness level measurement tools that were developed. Questions were designed and administered on-line through the Internet; answers to these questions were then used to determine the level of smartness of each system. These questions were asked to stakeholders of each supporting system, depending on the role of each stakeholder. In addition, each director was asked how the goals of the work unit could be achieved within the existing limitations. A screenshot of each answer in the program was then attached, so that each answer could be accounted for. The results of the questionnaire were then validated by random interviews with campus administrators.

Table 6 contains the results of the assessment of the HEI system using a technology-based system smartness model.

Table 6: Measurement of the smartness level.

No	Campus name	E-learning	Academic	Admissions	E-office	Dashboard	HR	Finance	Library	Smartness level
1	Private A University Jakarta	2	2	2	1	1	2	2	1	1.63
2	Private B University Jakarta	3	2	2	2	2	2	2	2	2.13
3	Private C University Jakarta	3	4	4	3	4	4	4	4	3.75
4	Private D University Riau	3	2	2	1	1	1	1	2	1.63
5	Private E University Bandung	2	2	3	1	1	3	3	3	2.25
6	Public A University Bandung	3	3	3	3	3	4	4	3	3.25
7	Private F University Jakarta	3	2	3	2	2	2	2	2	2.25
8	Public B Institute Surabaya	3	4	4	3	3	4	4	3	3.50
9	Private G University Surabaya	3	4	3	2	2	3	3	2	2.75
10	Private H Polytechnic Riau	1	2	2	3	2	3	2	1	2.00
11	Private I University Medan	3	3	2	2	2	2	2	2	2.25
12	Private J Institute Garut	1	3	2	2	2	2	2	3	2.13
13	Public C University Bandung	3	4	3	3	3	3	3	3	3.13
14	Private K University Jakarta	1	2	2	2	2	2	2	3	2.00
15	Private L University Bandung	2	2	2	2	2	2	2	2	2.00
16	Public D University Padang	2	3	2	2	2	2	2	2	2.13
17	Private M University Medan	1	2	2	1	1	2	2	1	1.50
18	Public E Institute Bogor	3	3	3	3	3	3	3	2	2.88
19	Private N University Jogjakarta	2	2	2	3	3	2	2	2	2.25
20	Public F University Medan	3	3	3	2	2	2	2	2	2.38
21	Public G polytechnic Semarang	1	2	2	1	1	2	2	1	1.50

22	Public H Institute Bandung	2	2	2	2	2	2	2	2	2.00
23	Public I University Jember	2	3	3	2	2	2	2	2	2.25
24	Private O University Jogjakarta	3	3	3	3	3	3	3	3	3.00
25	Private P Institute Jakarta	2	2	2	1	1	2	2	2	1.75
26	Private Q University Jakarta	3	3	3	2	2	3	3	2	2.63
27	Public I University Semarang	3	3	3	3	3	3	3	2	2.88
28	Private R University Bandung	1	2	2	1	1	1	1	1	1.25
29	Private S Institute Bogor	1	2	1	1	1	1	1	1	1.13
30	Private T University Bandung	3	3	3	3	3	4	4	3	3.25
31	Private U University Jogjakarta	3	3	3	3	4	4	4	3	3.38
32	Private V University Tegal	0	1	0	0	0	0	0	0	0.13
33	Private W Polytechnic Salatiga	1	1	1	0	0	0	0	0	0.38
34	Private X Institute Majalengka	0	1	0	0	0	0	0	0	0.13
35	Public J University Ambon	2	1	1	1	1	1	1	1	1.13
36	Private Y Institute Indramayu	0	1	0	0	0	0	0	0	0.13

Evaluation of the Smart System Model and Smartness Levels

The expert judgment method was used to evaluate the levels of system smartness of the representative model in terms of the degree of technology used to run the smart cycle. Expert lecturers and researchers from several HEIs in Indonesia who had more than ten years of experience in their fields were invited to attend a Zoom meeting to receive an explanation of the smartness levels of the proposed technology-based system and answer some questions prepared beforehand.

Table 7: Experts involved in evaluating the model.

No	Name	Academic experience	Position
1	YMD	21 years	Lecturer, former vice-rector
2	FP	24 years	Lecturer, vice-president of APIC *Smart Campus*, dean from 2011
3	OCP	30 years	Lecturer, vice-rector from 2016
4	TMZ	15 years	Lecturer, dean
5	W	12 years	Lecturer, vice-rector
6	SS	30 years	Professor, chairman of the university senate
7	ACN	27 years	Lecturer, former structural officer, researcher SCCIC
8	JK	23 years	Lecturer, department head
9	BRS	20 years	Lecturer, structural officer
10	SF	13 years	Lecturer, researcher SCCIC
11	AL	12 years	Lecturer, researcher SCCIC
12	OM	12 years	Lecturer, researcher SCCIC
13	MC	13 years	Lecturer
14	DE	20 years	Lecturer
15	DJS	20 years	Lecturer, vice-dean
16	A	19 years	Lecturer

The following questions were asked:

1. Can the concept of system smartness based on the use of technology be used to measure system smartness?
2. Do you have any input regarding the description/characteristic of each level of smartness?

In answer to question 1, all the experts stated that the concept of system smartness based on the use of technology could be used to measure system smartness. In answer to question 2, all experts agreed with the description of each level of smartness. There were several different inputs for level 4, where the written description of level 3 has been running for a long time with evaluation and improvement. It was evident that there needs to be a clearer time regarding the previous criteria in the question.

Input from TMZ's comments indicated the need for more significant differentiators, possibly merging the levels so that the maximum level is level 4. He also asked whether it would be possible to reduce levels to four or whether five levels were still needed. Input from all experts regarding the characteristics of each level will be taken into consideration in future studies.

Evaluation of the Smartness Level Measurement Tools

The obtained results were sent to the HEI leaders to ask for their clarification on whether the measurement results were in accordance with the conditions of technology usage in each system. A Google form was used with the following questions:

1. Would the results of the measurements be useful for them as leaders to find out the condition of the application of technology in the system on their campus?
2. Do the measurement results describe the current condition of their campus?
3. Was it easy to fill out the questionnaire?

Of the 36 HEIs, 25 HEIs sent back feedback. These are the results:

In answer to question 1, eight out of 25 respondents answered that the results of the measurements were very useful; 13 respondents answered that they were useful and four respondents answered neutrally (Figure 2).

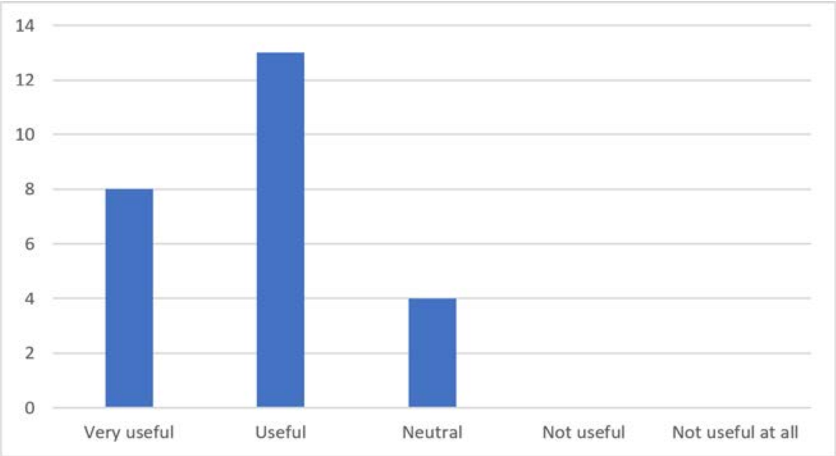

Figure 2: Answers to question 1.

In answer to question 2, ten out of 25 respondents answered that the measurement results were very representative of the condition of the existing system on their campus; 13 respondents answered that the measurement results represented the condition of the existing system on their campus and two respondents answered neutrally (Figure 3).

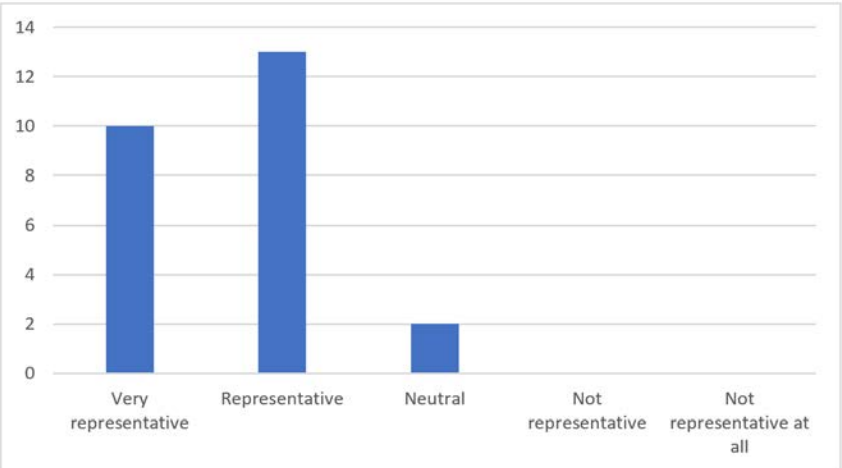

Figure 3: Answers to question 2.

In answer to question 3, eight out of 25 respondents stated that the questionnaire was very easy to fill out; 13 respondents stated that the questionnaire was easy to fill out and four respondents answered neutrally (Figure 4).

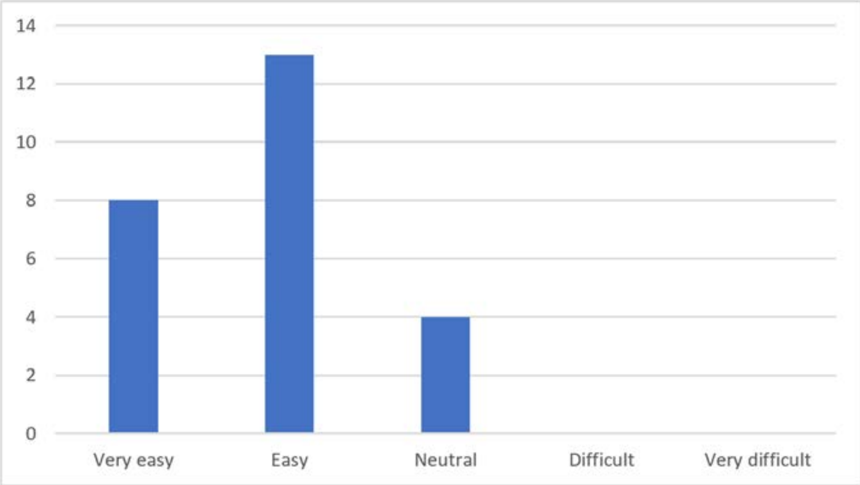

Figure 4: Answers to question 3.

The positions of the respondents who filled out the questionnaire are shown in Figure 5.

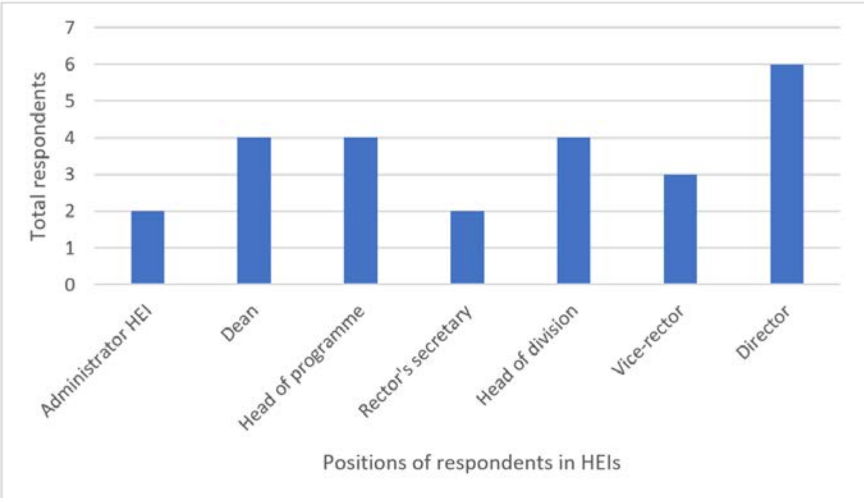

Figure 5: Total respondents per position.

To assess the content validity of the question items, content validity ratio (CVR) and content validity index (CVI) calculations was performed for each question item, with the CVR value exceeding 0.440 for CVR with a total of 25 respondents and the CVI value exceeding 0.8. Table 8 shows the CVR and CVI values for each question, demonstrating that all questions are valid.

Table 8: Content validity results.

	Number of panellists	CVR	CVI
Question 1	21	0.68	0.84
Question 2	23	0.84	0.92
Question 3	21	0.68	0.84

From the results of the measurement test conducted at 36 HEIs, it can be concluded that the measurement tool and the smartness level of technology usage can be replicated for use by anyone who wishes to measure system smartness based on the usage of technology.

CONCLUSIONS

In this study, a successful model has been designed that consists of six levels of system smartness in terms of the degree of the application of technology to run the smart cycle. The suitability of the model is supported by the evaluation results from 16 experts, none of whom opposed the model. However, additional input regarding the characteristics of each level of measurement has been received which will be considered in future research. The maturity model developed ranged from level 0, which is human-based smartness to super-smart level 5, where all smart cycles are run automatically by technology. The proposed model has been tested in 36 HEIs in Indonesia to measure the smartness of their systems. According to the levels of smartness, the supporting systems in these 36 HEIs are mostly at level 2, indicating that the existing systems have analytic capabilities for using machine learning or big data; however, humans still make the decisions. It still remains a challenge for these HEIs to develop increasingly smart systems. The measuring instrument that was made also has reproducibility and replicability because the research has been explained step-by-step, according to the DSRM research methodology.

The requirements of the smartness level measurement tools were tested by checking whether the questions used were valid and reliable. This was done by using the Pearson product-moment correlation, with IBM SPSS Statistics 25 [16]. The criteria used to determine whether the questions were valid are: the sig (p-value) < 0.05 and the value of r count $\geq$ r table. In this study, the r count for each question was > 0.8. Thus, it can be concluded that all the questions were valid. Reliability tests are also used to show the extent to which a measuring instrument can be trusted or found reliable. This study used Cronbach's alpha. If the Cronbach's alpha value is > 0.60, then the questionnaire is considered reliable or consistent. The questionnaire in this study obtained a Cronbach's alpha value of 0.833.

These measurements were carried out to ensure that this model can be used for the measurement of system smartness in all systems, not only in HEIs. It is viewed that this study contributes to the body of knowledge in the field of smart systems by enriching new or representational perspectives, as well as the field of new measurement models. The limitations of this study are that the measurement of system smartness was only taken from the point of view of the use of technology and other aspects, such as the service quality of the system, were not considered. In addition, the testing of the measuring instruments that were made was only done in an HEI environment. In the future, these instruments need to be tested in the smart city environment, as well as other environments.

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